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(54) Dental hygiene device

(57) A dental hygiene device comprises an n-type semiconductor (4) disposed on or in a main body (3) consisting of an inserting portion (1) and a handle (2). At least one portion of the semiconductor is exposed, while at least another portion is located at the inserting portion of said main body. The semiconductor (4), when irradiated with a natural light, is activated to produce therein a number of holes whereas teeth become reverse-phased due to an electron density higher than that in the semiconductor to thereby give rise to a reduction which decomposes tartars and coloured scales on the teeth.

Fig. 1

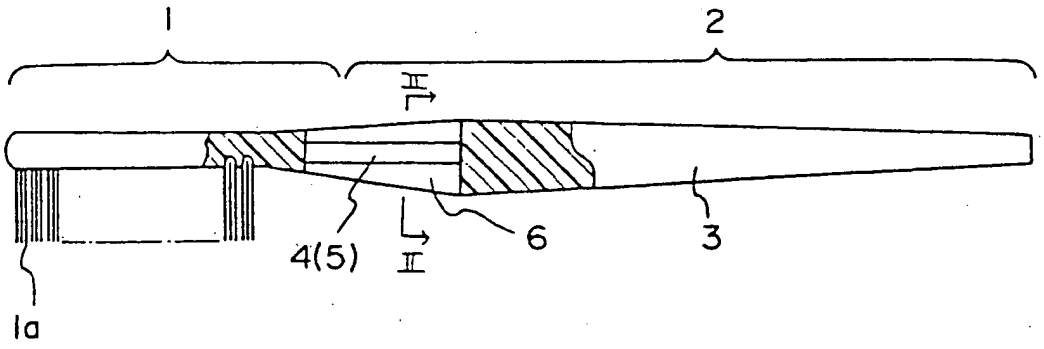

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Fig. 1

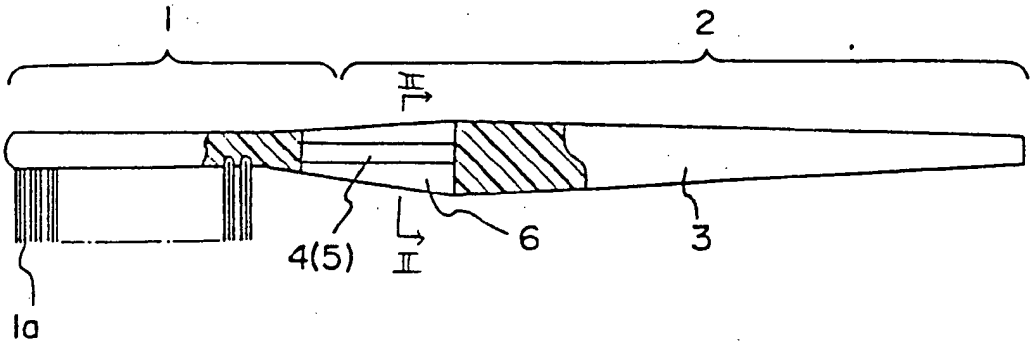


Fig. 2

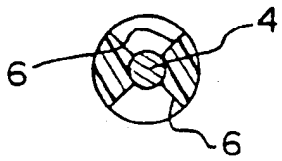


Fig. 3

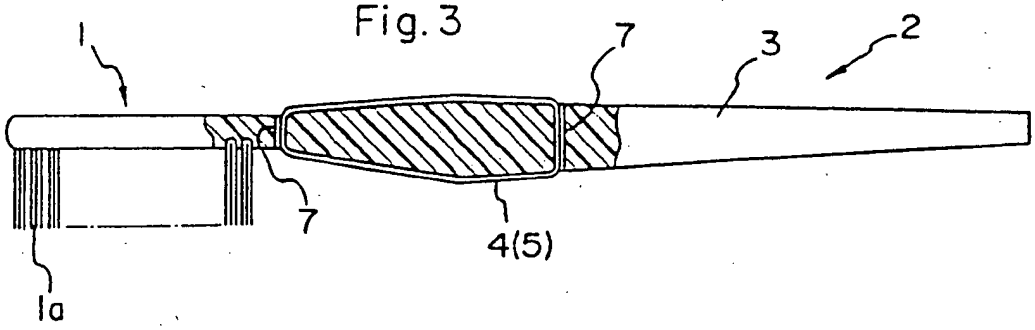


Fig. 4

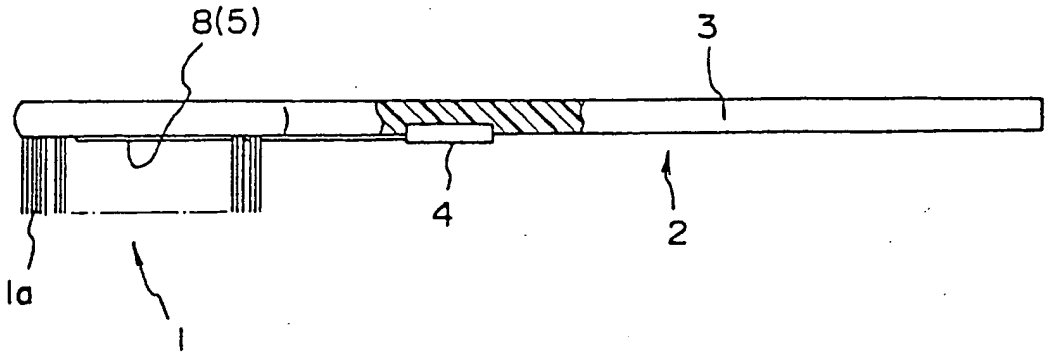


Fig. 5

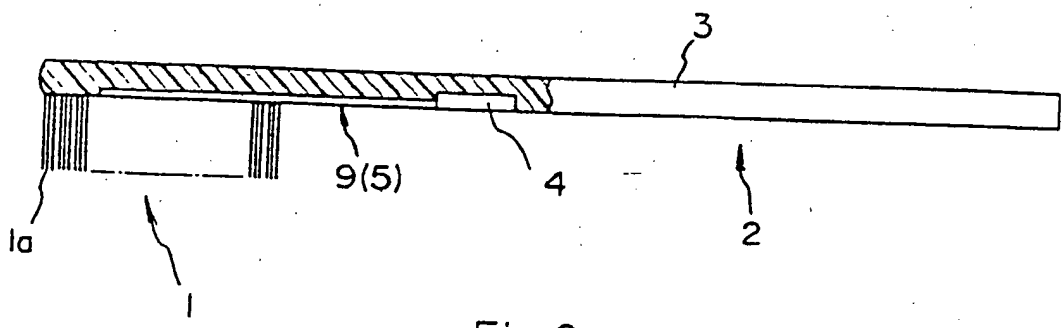


Fig.6

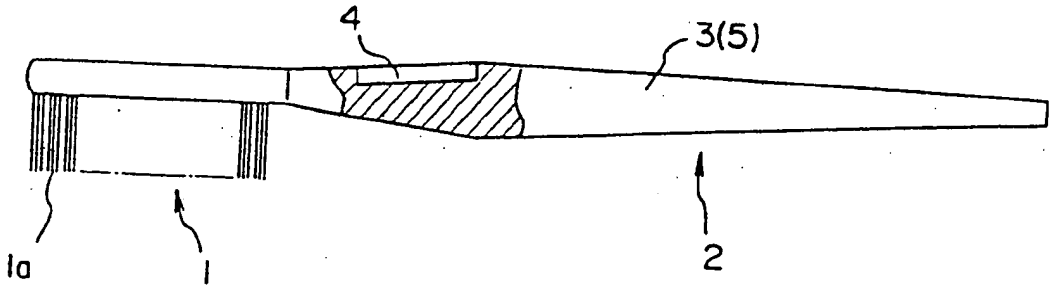
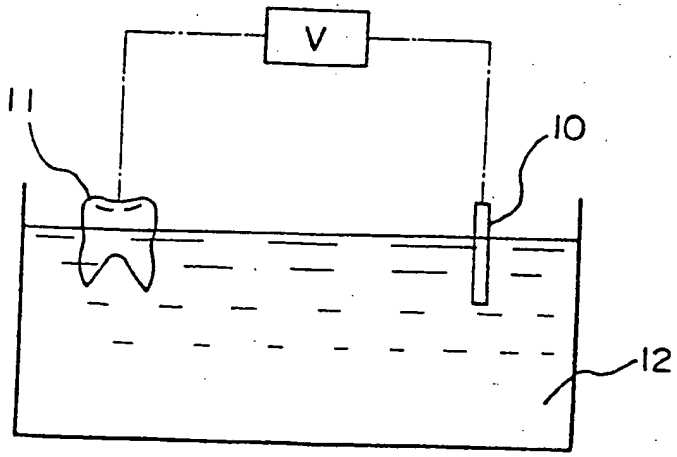


Fig. 7



SPECIFICATION

Dental hygiene device

The present invention relates to a dental hygiene device having a stucture based on and utilizing a photoelectric chemical reaction, and more particularly to a dental hygiene device adapted to improve the sanitary condition of teeth by means of an electrical polarization and a chemical reduction which are produced by electrical energy that is converted from photoenergy by a semiconductor in conjunction with a light beam, water and teeth.

Tooth powders or pastes often contain an amount of one or more fluorine compounds because said compounds have proved to be effective for the health of teeth.

However, the teeth surfaces are liable to prevent anions such as fluorine from permeating the teeth since the teeth are covered with a saliva which has a pH value lower than that of the teeth. It has therefore been very difficult to obtain a satisfactory effect from said anions.

In order to solve such a problem, it has been proposed that a cathode is attached to a brushing head of a toothbrush. In the use of such device, a teeth-ridge or teeth per se will act as a cathode whilst a human body functions as a conductor, whereby in the presence of saliva and/or drinking water an electrolytic reaction takes place as follows:

$$H_2O \rightarrow 1/2O_2 + 2H^+ + 2e^- \quad \text{... (anode reaction),}$$

$$2H^+ + 2e^- \rightarrow H_2 \quad \text{... (cathode reaction)}$$

and as the result,

$$H_2O \rightarrow 1/2O_2 + H_2.$$

The above reaction has seemed to improve the permeability of fluorine ions.

This technique is however not convenient in that it needs a comparatively large consumption of electric power for such reactions since the human body, the electric resistance of which is high, is used as a circuit component. Its further disadvantage resides in a fact that there is a considerable difference between individuals as regards their electric resistance, to such a degree that a required current strength for such reactions might not be achieved. Moreover, a misapplication of a high voltage which would overcome the problem will harm the human body. Hence, a novel technology has been sought which would not have the above drawbacks in the electrolysis notwithstanding the utilization of electric energy.

It is an object of the present invention to provide a dental hygiene device effectively adapted to reduce or overcome the problems in the prior art and to decompose and remove tartar and coloured scale from teeth in order to protect them from the decay of dentin or from internal purulence of the gums closely holding the teeth, the device being effective also to prevent "ash-extraction" caused otherwise by a lower pH value of the teeth.

According to the invention a dental hygiene device comprises a fundamental member or main body provided with an inserting portion to be inserted into an oral cavity, and an n-type semiconductor having a photoelectric effect and disposed on or in the main body so as to be partially exposed while also partially being located at the inserting portion of said main body.

An important difference between the prior art and the present invention resides in the fact that the former utilizes electrolytic reactions whereas the latter makes use of the so-called photoelectric chemical reaction which includes or gives rise to the reactions generally occurring in electric cells, i.e. oxidation and reduction.

Said oxidation and reduction do not merely mean such a bonding of oxygen with or dissociation thereof from a certain substance that is observed in combustion, corrosion or any other chemical reactions. It should be understood that it is meant here by the word "oxidation" or "reduction" that electrons are taken from or given to any concerned substance, as in modern chemistry. This concept has, as is well known, originated from an electrical understanding of the ionic bonds, especially of the oxidations and reductions involved in chemical reactions.

The characteristics of the invention will now be explained in greater detail.

The n-type semiconductor having a photoelectric effect will be inserted into and withdrawn from an oral cavity when the teeth are brushed. Said semiconductor will be electronically excited when it is irradiated with a natural light, and at the same time it will be given a number of holes caused by an electric potential difference between it and an electrostatic layer formed in the air in contact with the semiconductor. The electric holes make the teeth polarized and become an anode, as well known in the art. Namely, this phenomenon is an intrinsic function of such semiconductors as indicated above.

On the other hand, the teeth will become reverse-phased in polarity due to their electronic density different from (i.e. higher than) that of said semiconductor. Namely, the teeth become a cathode. Therefore, saliva or water near the semiconductor within the oral cavity will give electrons to said holes of the semiconductor. Thus, the saliva or water will be oxidized. A reduction will simultaneously take place at the teeth or the tartar deposited thereon while they are obtaining electrons from the saliva or water.

It is to be emphasized that the reactions occurring in electric cells as well as the oxidation and reduction will take place at the same time, the former being observed between the semiconductor functioning as the anode and the teeth functioning as the cathode whereas the latter are observed with the photo-irradiated semiconductor accepting electrons from the saliva or water near the semiconductor, and with the teeth and tartar accepting electrons from the saliva or water near the teeth and tartar. Consequently, the above reduction will thus neutralize the teeth whose pH value has been lowered by the tartar and scale so that the ash-extraction due to the low pH can be remarkably avoided.

The aforementioned polarization will decompose the coloured scale and the tartar causing the decay whereby the gum purulence as well as the decay are efficiently checked while the teeth are kept more beautiful.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of one embodiment of a dental hygiene device according to the invention, with a surface portion partially cut away;

Figure 2 is a vertical section of the device along lines II-II in Figure 1;

Figures 3 to *6* respectively show further embodiments each illustrated with a part cut away, similar to Figure 1; and

Figure 7 schematically shows an experimental device.

Figures 1 and 2 illustrate one embodiment of dental hygiene device according to the invention that is embodied in a toothbrush by attaching thereto a semiconductor (of n-type having a photoelectric effect, this type will be referred to hereinafter). A fundamental member or main body 3 is made of a suitable plastics and comprises an inserting portion 1 and a handle 2, the portion 1 having, as usual, a brush 1*a* upstanding therefrom and adapted for insertion into an oral cavity (not shown) while the handle 2 is positioned exteriorly of the cavity in use of the device. The numeral 4 indicates a semiconductor which is of a wire shape (having a diameter of about 3 mm, or it may be of a ribbon shape) and is embedded in the main body 3 so as to extend from the inserting portion 1 to the handle 2. In such a structure as described above, the semiconductor per se functions as a conductive material for photoelectrons. Grooves 6 formed in the main body 3 are utilized for embedding the semiconductor during manufacture of the device while on the other hand acting as a pool in use thereof. The body 3, when it is transparent, may almost entirely embed the semiconductor 4 with an internal end thereof exposed such that it may be in contact with a saliva or water in the oral cavity.

In another embodiment shown in Figure 3, one or two pieces of semiconductor extend through apertures 7, 7 to thereby form a closed loop exposed on the front and/or backside of the main body 3. Other parts are similar to those in Figure 1 so that the same reference numerals have been given to them without any further description thereof. The same comment applies to the following embodiments.

In yet another embodiment illustrated in Figure 4, a small-sized semiconductor 4 is secured to a handle 2. A conductive wire 8 extends from the semiconductor to an inserting portion 1 thereby to conduct photoelectrons.

In a further embodiment shown in Figure 5, a groove 9 is formed on a main body 3 so as to hold an amount of water or saliva therein which acts as a conductive line for photoelectrons instead of the wire 8.

In yet a further embodiment shown in Figure 6, the main body 3 itself is of a conductive material (which should be harmless to human bodies).

An example of a preferable semiconductor 4 is titanium dioxide (TiO_2) which may be produced by intensely heating an elemental titanium (Ti) at 1200 to 1500°C in an incandescent state for 2 to 5 minutes. It is of course possible, however, to make use of any other kind of semiconductor which may give rise to a photoelectronic current of a suitable intensity when exposed to natural light (including some semiconductors that are treated with pigments or complex compounds to increase their quantum coefficiency). As for the shapes or states of the semiconductors, they may be plates, wires, ribbons or sintered or coalescent powders.

In order to prove that a photovoltaic or photoelectromotive effect is present in the use of the above devices, a simulation test was executed with an apparatus as schematically shown in Figure 7. A TiO_2 stick 10 having a surface area of 1.2 cm^2 was immersed within distilled water 12 together with a drawn decayed tooth 11 spaced apart from the stick. A receptacle containing the distilled water was placed in a room (when raining, at evening) and then the photovoltaic effect was measured. There was found that a photoelectromotive force of about 10 to 50 mV, which is sufficient for the aforementioned sanitary effect, was taking place under influence of the indoor natural light.

The main body 3 may be designed to have any shape other than the exemplified shapes without limiting the scope of the invention. The brush hairs 1*a* may be omitted from the main body, which may be provided with an attachment adapted to spray a teeth cleaning solution.

The semiconductors may be additionally activated by means of an external voltage so as to amplify the photoelectric effect, within the scope of the invention. The TiO_2, which is optionally used in the device of the invention may be produced or prepared according to any one of the following methods instead of the aforesaid method: namely,

(1) production and utilization of monocrystals;

(2) vacuum metallizing of a thin TiO_2 layer onto a metallic Ti by means of the chemical vapour deposition

(CVD) method or other methods;
(3) calcination of pelletized TiO_2 powders; and
(4) production of a metallic Ti by means of the anode oxidation.
It is reasonably assumed that the TiO_2 as the semiconductor 4 gives ris to the following reactions when irradiated with the light. Nam ly,

$$TiO_2 + h\gamma \rightarrow e^- + p^+,$$

$$H_2O + 2p^+ \rightarrow 1/2O_2 + 2H^+ \quad \text{(on the } TiO_2\text{), and}$$

$$2H^+ + 2e^- \rightarrow H_2 \quad \text{(on the teeth).}$$

These reactions mean that the n-type semiconductor having the photoelectric effect will be activated by light to release photoelectrons, which in turn build up an electric potential gradient between the semiconductor surface and an electrostatically charged atmosphere surrounding said surface, thereby producing a number of holes in the semiconductor. The teeth consequently become reverse-phased in their polarity due to a difference in electron concentration between them and the semiconductor. Thus, an oxidation occurs in the vicinity of the semiconductor thereby releasing electrons from the saliva or water while the latter gives electrons to the teeth thereby giving rise to a reduction on the teeth.

CLAIMS

1. A dental hygiene device comprising a main body provided with an inserting portion adapted to be inserted into an oral cavity, and an n-type semiconductor having a photoelectric effect and disposed on or in the main body in such a manner that at least a portion of said semiconductor is exposed while at least another portion thereof is located at the inserting portion of said main body.
2. A device as claimed in claim 1, wherein the semiconductor is a titanium dioxide manufactured by intensely heating an elemental titanium at 1200 to 1500°C in an incandescent state for 2 to 5 minutes.
3. A device as claimed in claim 1 or 2, wherein the semiconductor is formed in the shape of a bar and embedded in the main body which has grooves to provide pools for saliva or water and to expose the semiconductor.
4. A device as claimed in claim 1 or 2, wherein the semiconductor is provided with a conductive wire extending therefrom to the inserting portion.
5. A device as claimed in any preceding claim and having a brush, wherein the brush is upstanding from the inserting portion so as to impart a toothbrush function to the device.
6. Dental hygiene devices substantially as hereinbefore described with reference to Figures 1 and 2, or Figure 3 or Figure 4 or Figure 5 or Figure 6 of the accompanying drawings.

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